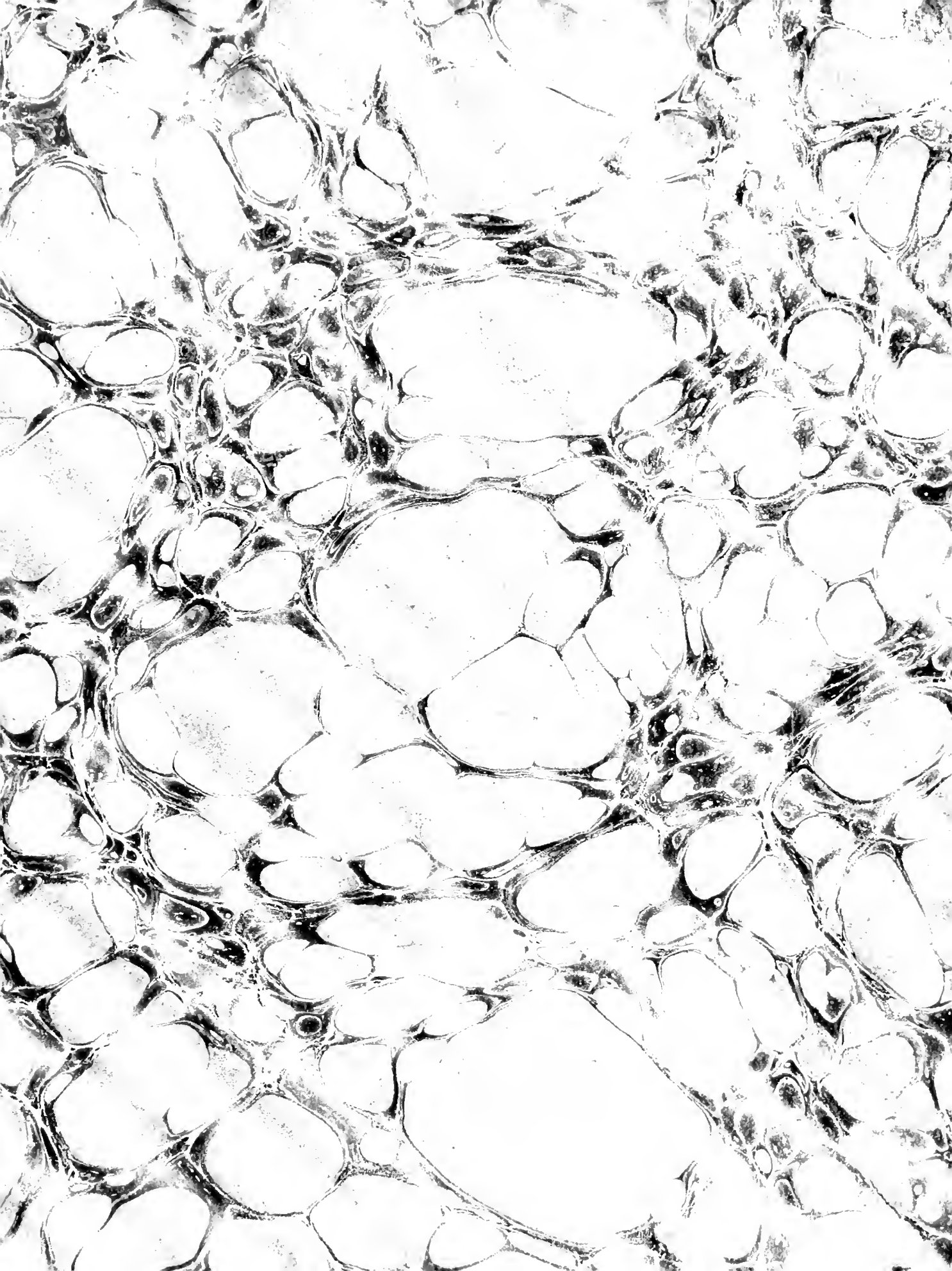


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THE UNITED STATES OF AMERICA

$\frac{e}{h}$

TO THE HONORABLE SENATE OF THE UNITED STATES

OF THE DISTRICT OF COLUMBIA,

REPORT

BY

S. J. ALLEN,

U.S.

AND

REPORT

ON THE PROGRESS OF THE WORK OF THE COMMISSIONERS OF THE LAND OFFICE

OF THE DISTRICT OF COLUMBIA, FOR THE YEAR

ENDING DECEMBER 31, 1900.

DECEMBER 31, 1900.

U.S.

1901.

1901.



THE VELOCITY OF THE  $\frac{e}{m}$  FOR THE  
 PRIMARY AND SECONDARY ELECTRONS  
 IN RADIUM.

C. J. JOHNS.



























rolled parallel to the electric field. The electric field was then reversed, and the particles were deflected by the magnetic field. The deflection was measured, and the velocity of the particles was calculated. The results showed that the velocity of the particles was constant, and that the electric field was apparently increased to the velocity of light was increased.

The theory was first developed by Lorentz, and elaborated by Heaviside, Larmor, and others, whereby the mass of the electron is considered as entirely electrical in its nature, and increases with the speed of the electron, reaching at the velocity of light a definite value. The later values of  $\frac{e}{m}$  obtained by Kaufmann agreed very well with those calculated from the first value of  $\frac{e}{m}$ .



these results are in good agreement.

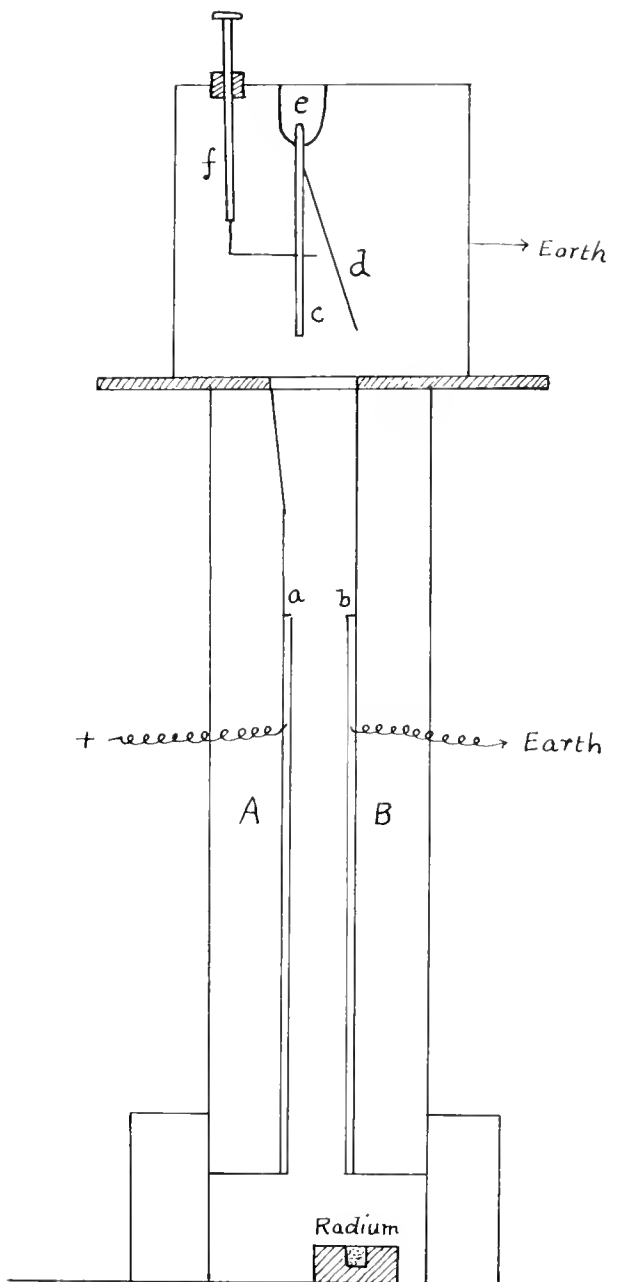
#### MECHANICAL EFFECTS

The mechanical effect of the vacuum on the rate of diffusion is referred to the vacuum die, and the results are shown in Table I. It is found that the rate of diffusion is not affected by the vacuum. In the final experiments a differential electrometer was used, but it was found that it was not possible to shield it sufficiently from electrostatic influences sufficiently to obtain accurate readings. It was therefore replaced by a sensitive gold leaf electroscope which could be shielded very easily from the effects of the high voltage fields used.

#### Experiment I.

The first experiment was tried in air at atmospheric pressure, at the general arrangement as is sketched in Fig. 1. Two zinc plates 18 cm. long were attached to localization devices and held in place in a vertical position about 4 mm. apart. At the bottom of the plates was placed a block of lead containing some radium oxide, covered with a thin sheet of mica which allowed the  $\alpha$  rays to pass through





- Fig I -



is out as a result of the ionization of the air. The ionization is produced by the  $\alpha$  rays which are emitted from the source. The  $\alpha$  rays are emitted from the source in a straight line and strike the plate b, which is at a distance of 1 cm. from the source. The  $\alpha$  rays are stopped by the plate b, but the ionization of the air is still sufficient to cause the leaf to fall.

Over the top of the plates the air is connected to an electroscope, the details of which are shown in the figure. The rod c containing the gold leaf was insulated from the case by means of a piece of ebonite. The system was charged to a potential of a few hundred volts by means of the rod d, which could be turned so as to touch the rod holding the gold leaf. At other times it was connected to the case, which was earthed. The bottom of the electroscope had a thin aluminium window through which the rays could pass. The time which the gold leaf took to fall through a fixed distance on the cross hair of the telescope was taken as a measure of the ionization. Part of this ionization was due to the  $\beta$  and secondary rays, and part to the  $\gamma$  radiations, and these could be distinguished from one another by means of tests. Of the total about 60% was due to the  $\gamma$  rays, the remainder to  $\beta$  and secondary rays.

If now the plate b is charged positively, then the  $\alpha$  rays can be collected away from the plate.



the decrease of the ionization current, the average value of the ionization current was found since no fresh ions could be formed in the absence of the ionizing rays. It was also found that different velocities of the ions could be only observed when the ions were deflected by the electric field, but not when they were deflected by the magnetic field. The deflection of the ions by the electric field was observed only when the ions were deflected by the electric field.

The plates were connected to a battery of small lead accumulators, from which a maximum voltage of 5000 volts could be obtained. In the present experiments the number of cells was increased so that a potential difference of about 2000 volts was available. When a difference of about 1000 volts was applied to the plates no appreciable decrease of the ionization in the electroscope could be observed. The rays were completely deflected by means of a magnetic field but the value of  $H$ ,  $H$  being the strength of the magnetic field, and the radius of curvature of the deflection was calculated from this deflection was over five times what it should have been calculated from theory.



The expression for deflection of a ray in a uniform electrostatic field is,

$$\delta = \frac{X e}{m V^2} d \left( \frac{d}{2} + h \right)$$

where  $\delta$  represents the deflection,  $d$  the distance travelled by the ray in the field,  $h$  the distance from the top of the plates to the electrode,  $\frac{e}{m}$  the ratio of charge to mass of the electron,  $V$  the strength of the electric field, and  $V$  the velocity of the electron. For the experiment  $d = 15$  cm.,  $h = 1$  cm.,  $X = 1$  cm., and  $K = 5 \times 10^4$  e.s. units.

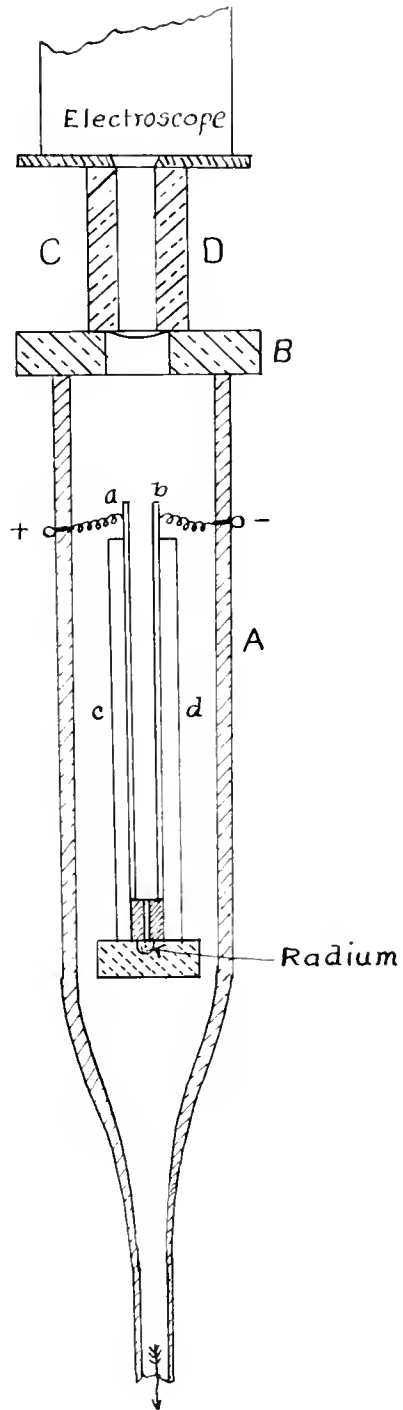
If we use 10 for  $V$ , and  $\frac{e}{m} = 1.76 \times 10^{10}$  e.s. units, we find by substitution, viz.,  $2.65 \times 10^{-7}$  cm. per sec. and  $1.65 \times 10^{-7}$  cm. calculated value of the electrostatic deflection for the highest velocity rays accounts for a deflection which should have been observed since the width of the window of the electrode was only 15 cm.

This failure to observe the electrostatic deflection could not at first be satisfactorily explained, and it was only after a number of experiments of different conditions were made that the true explanation was reached. I shall return to this point later on.









- Fig II -







The first of these is the fact that the value of  $\alpha$  is not constant over all values of  $\lambda$ . The value of  $\alpha$  is a function of  $\lambda$  and is given by the equation  $\alpha = \lambda / (1 + \lambda^2)$ . The value of  $\alpha$  is also a function of the value of  $\lambda$  and is given by the equation  $\alpha = \lambda / (1 + \lambda^2)$ . The value of  $\alpha$  is also a function of the value of  $\lambda$  and is given by the equation  $\alpha = \lambda / (1 + \lambda^2)$ . The value of  $\alpha$  is also a function of the value of  $\lambda$  and is given by the equation  $\alpha = \lambda / (1 + \lambda^2)$ .

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### Experiment III.

The experiment was carried out in a similar manner to that of Experiment II. A series of glass tubes, 20 cm. in diameter, 10 cm. in length, were arranged parallel to one another, 10 cm. apart from one another. The tubes were filled with water, and the water was allowed to flow through them. The water was allowed to flow through them at a rate of 10 cm. per second. The water was allowed to flow through them at a rate of 10 cm. per second. The water was allowed to flow through them at a rate of 10 cm. per second.



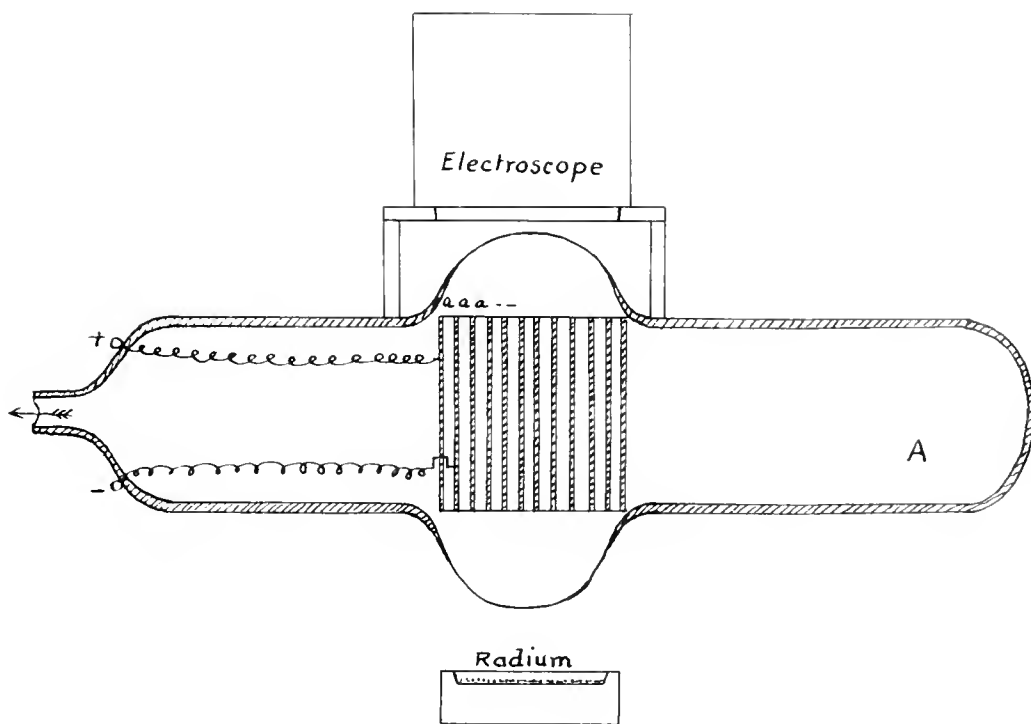


Fig IV















ties of the deflection of the beam to the surface of the  
 cathode decided to make a cathode of the type of  
 the cathode of the vacuum tube. The effect of the cathode  
 activation I would like to determine two or three times  
 the 3 mm. cathode by the photostatic method.

#### PHOTOGRAPHIC EXPERIMENT.

Experimentally, the arrangement used in this is es-  
 sentially the same as that used by Debye<sup>1</sup> and is  
 shown sketched in fig. 1. Two metal plates about 1  
 1/2 cm. in length were placed parallel to each other  
 in a vertical position 1 cm. apart, and insulated by  
 means of ebonite. About 2 cm. below the plates was  
 placed the radium contained in a narrow capsule in a  
 block of lead. In the centre of the radium, a lead  
 sleeve or a plate was fastened a sheet of mica, which  
 extended from the radium up to the photographic plate.  
 The plate was wrapped in a sheet of black paper, and then  
 placed inside a light tight container. The container was  
 filled with a gas of low pressure, and the whole  
 was evacuated. The distance between the top of  
 metal plates and the photographic plate was 1 cm.

The photographic plate was exposed to the radiation  
 for a period of 10 minutes and the plate was developed.



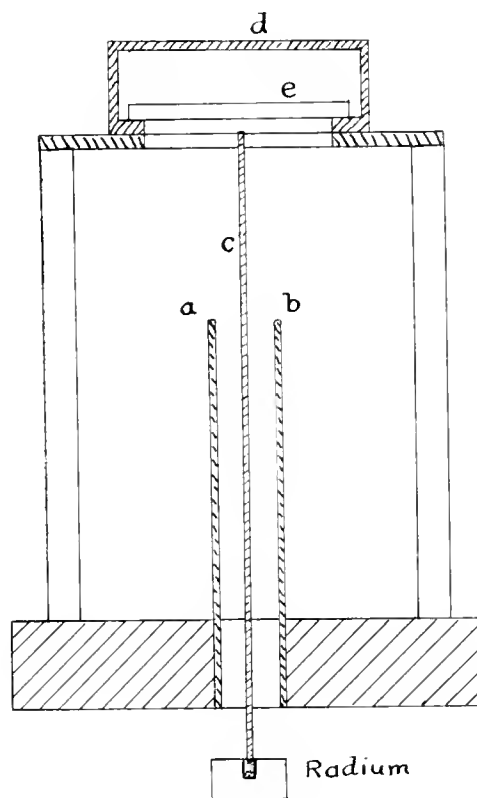


Fig. V.



1. The first step in the process is to identify the problem. This is done by gathering information about the problem and its causes. The next step is to develop a plan of action. This plan should outline the steps that need to be taken to solve the problem. The third step is to implement the plan. This involves putting the plan into action and monitoring the progress. The final step is to evaluate the results. This involves assessing the effectiveness of the plan and making any necessary adjustments.

2. The second step in the process is to develop a plan of action. This plan should outline the steps that need to be taken to solve the problem. The next step is to implement the plan. This involves putting the plan into action and monitoring the progress. The final step is to evaluate the results. This involves assessing the effectiveness of the plan and making any necessary adjustments.

3. The third step in the process is to implement the plan. This involves putting the plan into action and monitoring the progress. The next step is to evaluate the results. This involves assessing the effectiveness of the plan and making any necessary adjustments.

4. The fourth step in the process is to evaluate the results. This involves assessing the effectiveness of the plan and making any necessary adjustments.

5. The fifth step in the process is to make any necessary adjustments. This involves evaluating the results and making any necessary changes to the plan.

6. The sixth step in the process is to make any necessary changes to the plan. This involves evaluating the results and making any necessary changes to the plan.

7. The seventh step in the process is to make any necessary changes to the plan. This involves evaluating the results and making any necessary changes to the plan.

8. The eighth step in the process is to make any necessary changes to the plan. This involves evaluating the results and making any necessary changes to the plan.

9. The ninth step in the process is to make any necessary changes to the plan. This involves evaluating the results and making any necessary changes to the plan.

10. The tenth step in the process is to make any necessary changes to the plan. This involves evaluating the results and making any necessary changes to the plan.



Fig. VI.







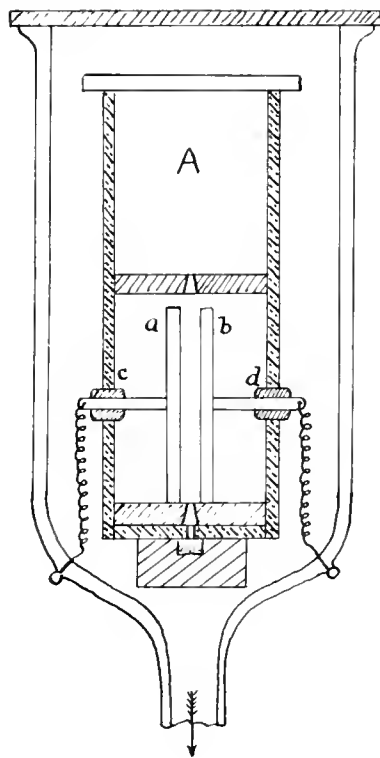


Fig. VII.







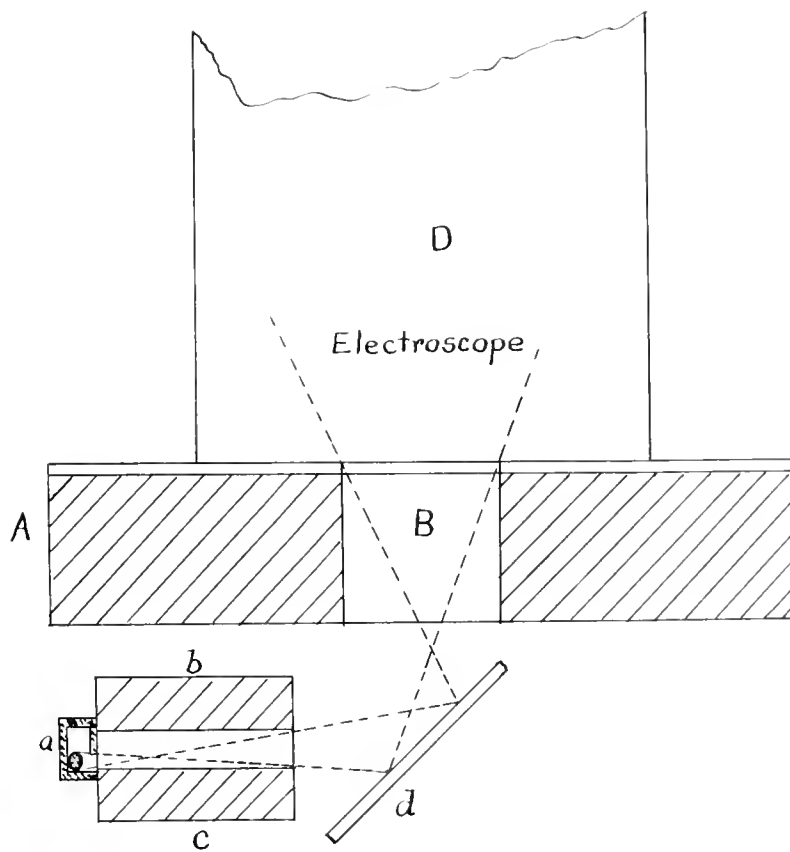


Fig. VIII.











Indicator = Zinc.

Total rate of sink	Rate of sink due to error carrying	Rate of sink due to technical error	Rate of sink due to other	
10.00	7.10	0.50	100	et
8.35	5.75	0.50	31	et
7.70	4.80	0.50	10	et
6.11	3.11	0.50	18	et
4.74	1.74	10	23	were placed
4.09	1.09	20	11	directly
3.53	0.43	40	0	radiation
3.26	0.1	10	21	

Indicator = Zinc.

15.00	11.30	0	100	drinks only
4.51	1.51	0	11	across
4.15	1.06	0	37	sheets of
3.50	0.70	10	37	paper
3.32	0.72	0	100	were placed
3.59	0.49	20	00	piece of
3.42	0.32	30	11	zinc
3.41	0.21	10	23	











to the other side of the river, and the  
 water level was found to be higher than  
 the other side of the river. The water level  
 had moved to be the most efficient, and the  
 of the water level was found to be higher  
 on the other side of the river. The water level  
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Table 13.

Years	Primary	Secondary	Other
0	100	100	100
1	90	80	
2	80	70	50
3	70	60	40
4	60	50	30
5	50	40	20
6	40	30	10
7	30	20	5
8	20	10	2
9	10	5	1
10	5	2	0
11	2	1	0







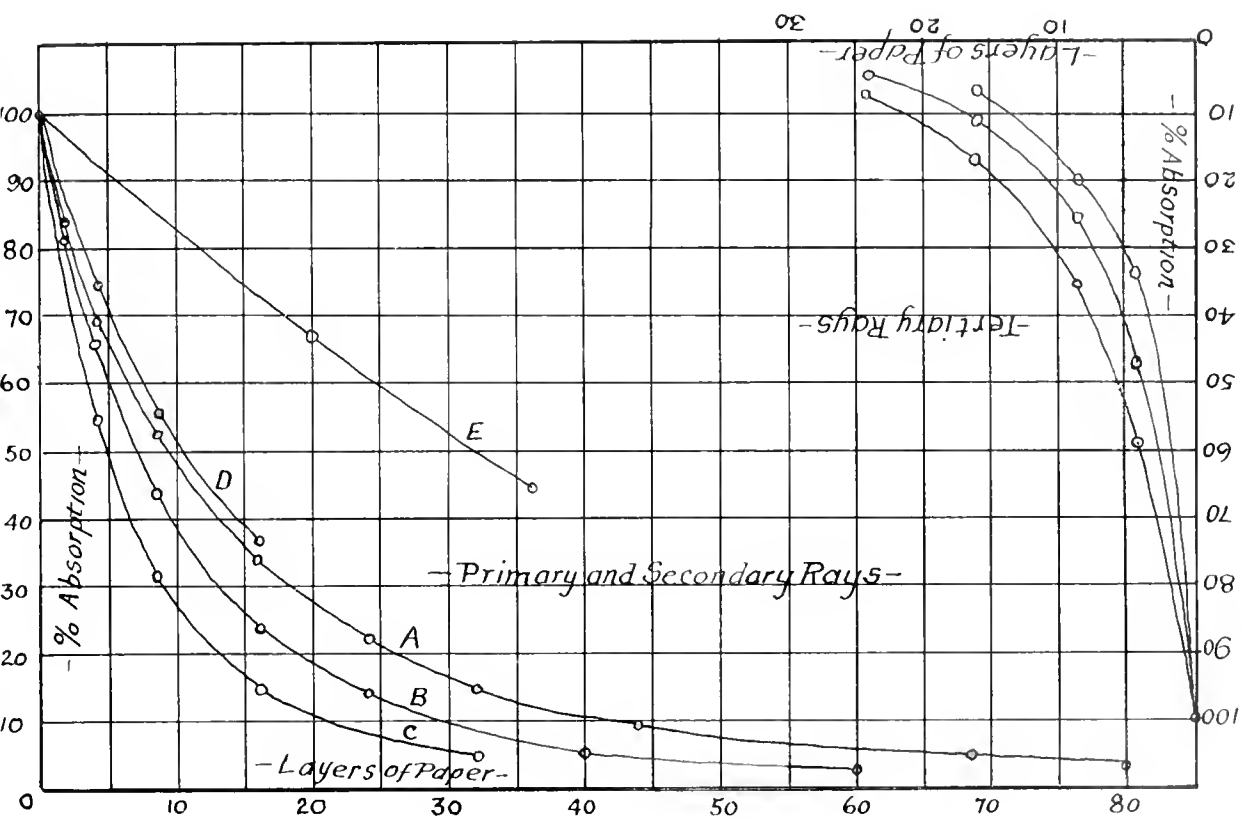


Fig. IX.



explained. The results of the first series of experiments  
 in which the speed of the air stream was varied, the  
 results were performed with a constant air stream  
 velocity of 100 ft. per sec. The results of the  
 first series were as follows: The results of the  
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#### TABLE IV

Distance from the nozzle	Angle of deflection	Angle of deflection
0	0	0
30	30	30
60	60	60
90	90	90
120	120	120
150	150	150

The results show that the angle of deflection from  
 the nozzle and the distance from the nozzle are  
 of the same order of magnitude. The results of the  
 first series of experiments are as follows: The  
 results of the first series of experiments are as follows:  
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#### TABLE V

The results of the second series of experiments are as follows:  
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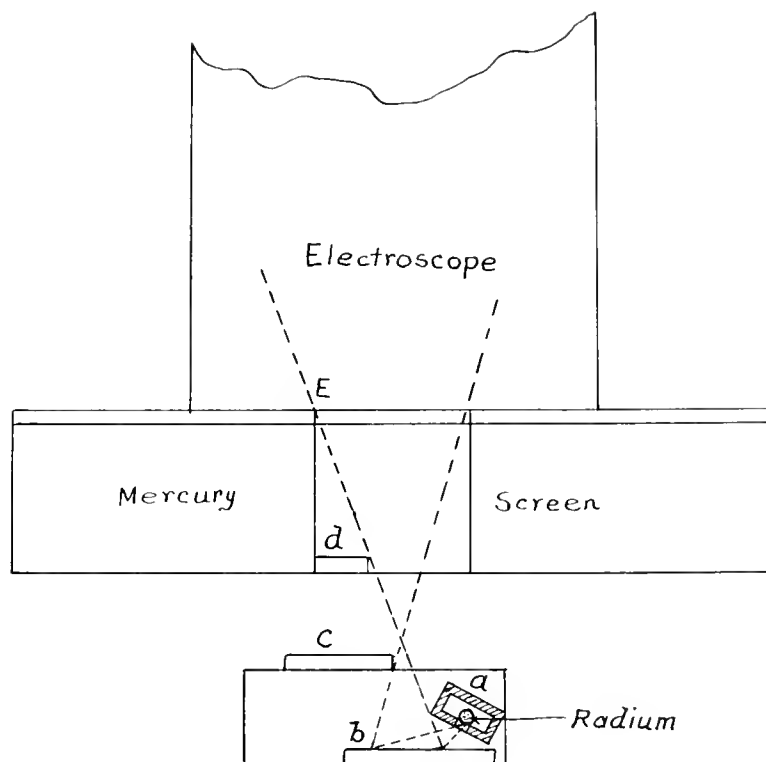


Fig.X.



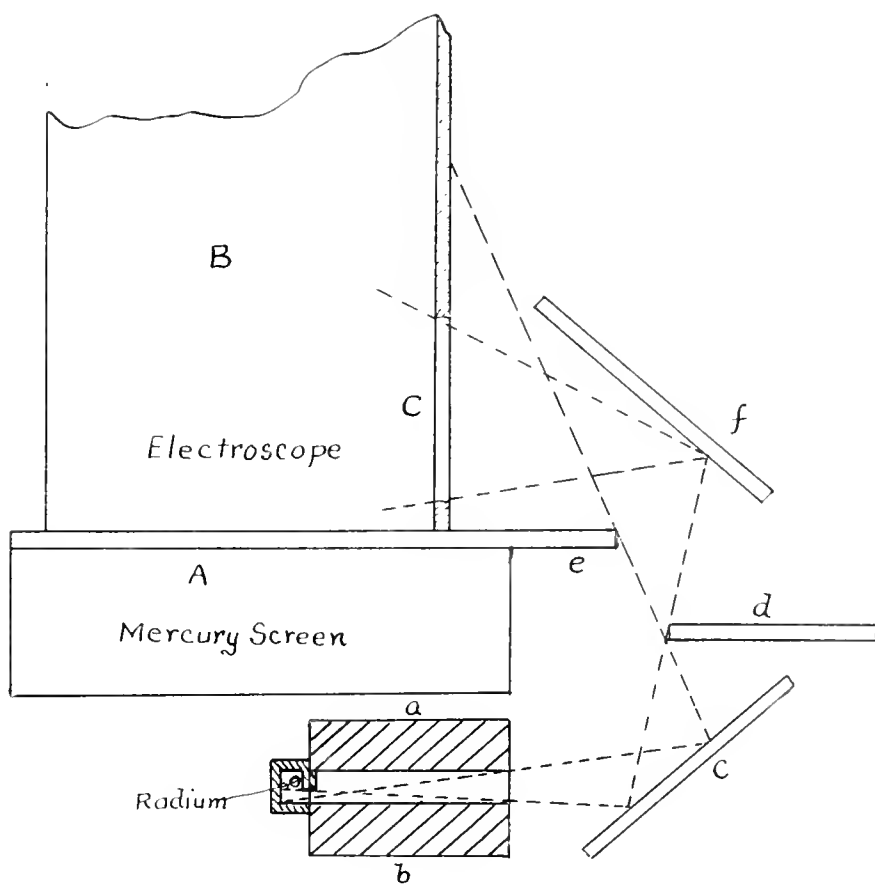




that  
A

When the screen is tilted in aid for the tertiary rays produced could travel upward at a larger angle to the screen. As by tilting the screen, the electric field conditions indicated in the figure, the rays could be diverted from a tertiary electrode of the same type. It would still be able to travel upward. The electric field was applied in the direction of the tertiary electrode of force were perpendicular, the condition of the tertiary of the power the tertiary electrode of the electrode was not appreciably altered, but when applied in the reverse





*Fig. XI.*







of about 1000 rads per hour. The dose rate in the  
stream of the secondary field is about 1000 rads per  
hour. The rate for the tertiary field is of the order of  $HR = 100$   
rads per hour. The secondary field is the most penetrating  
and deviates in a magnetic field in a direction opposite  
the direction of the primary radiation. The secondary field is  
relatively composed of particles travelling at speeds of 10  
million e.v. and the slowest 3 particles.

When the screen is placed in the radiation field as  
in the figure, it was found that the ionization in the  
electroscope was increased. This was found to be partly  
due to the secondary rays produced when the primary rays strike  
the screen, and also partly caused by the tertiary  
rays from below striking the screen, and are called  
forward type of rays.

The secondary radiation is most penetrating and can  
be shown by placing in front of the blocks a thin  
screen, sufficient to cut off all the secondary rays.  
In this case the forward rays are absent. The secondary  
would probably go on for a large number of radiations,  
but after the third the radiation is too feeble to be  
measured accurately. The range of radiation is a less  
penetrating power than the secondary produced it.











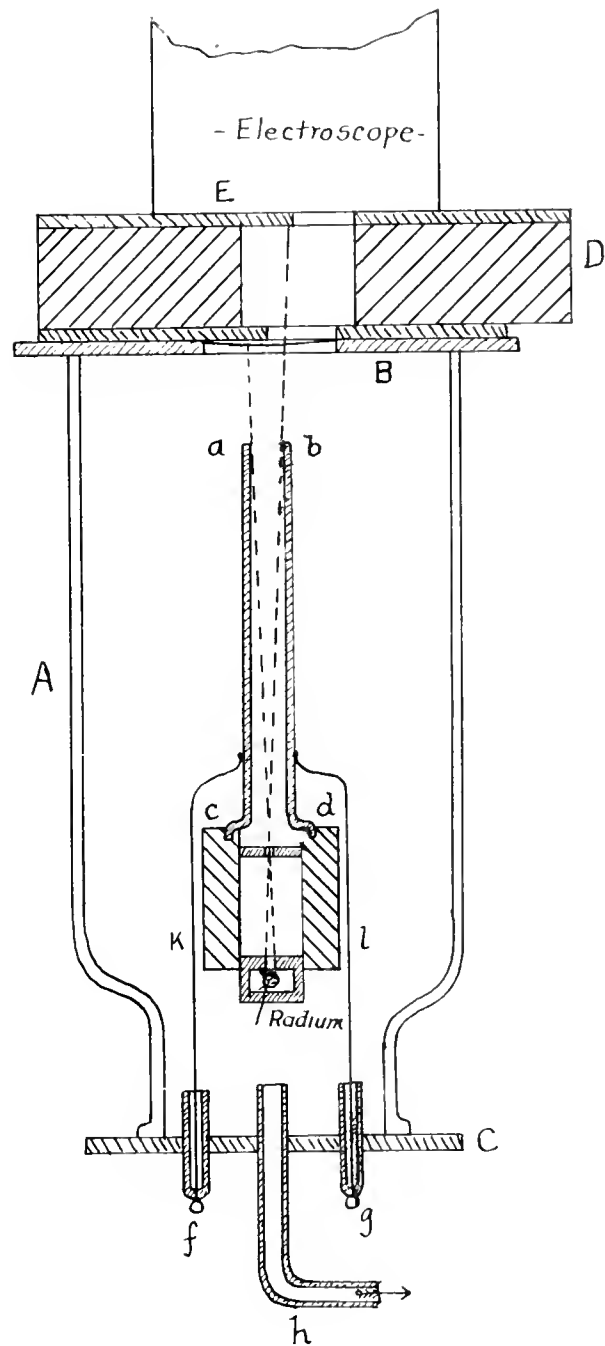


Fig. XII.







For the primary rays, the rate of ionization is  
in a broad band of light, the rays are concentrated  
toward the center of the field of view. The  
rate of ionization of the secondary rays is the same as of the  
primary rays, but will be revealed from  
the center of the field of view. The rate of ionization will  
however, be confused by the presence of a large number of  
secondary rays coming from various points. This can be illus-  
trated by some photographs taken at different points along  
the path of the rays. One taken from the upper slit  
shows a narrow fuzzy image, whereas one from the lower  
of the zinc plates the image is sharp and the full width of the  
covering. At the top of the plate B the image had again  
become indistinct. While at the top of the primary screen  
it was of the full width of the covering and of uniform  
density.

If the eye looking at the electroscope was arranged  
symmetrically with respect to the zinc plates, there was  
observed a decrease of ionization in the electroscope  
when the electric or electrostatic fields were applied  
in either direction. The decrease in the case of the  
electrostatic field was about 25 per cent, and in the case  
of fields of 1000 volts per centimeter. It is  
clearly that at the same time details of the electric  
field, though the field of view is large, the details are























following table.

absorbing Layer	$\Sigma(\max)$	$H(\max)$	$\frac{mV}{2}$	$\frac{mV}{e}$	$V$ cm/sec	$\frac{e}{m}$
of paper	3.7	11.0	12.5	1.87	2.47x10 <sup>8</sup>	1.1
10 "	1.1	11.5	1.76	1.98	2.4	1.1
14 "	1.1	13.2	5.13	1.17	1.15	1.1
18 "	7.2	17.1	1.32	1.31	1.42	1.1
22 "	7.7	17.2	1.61	1.37	1.4	1.07
30 "	3.5	17.9	5.15	2.19	1.0	1.01
1.5mm Zn (s)	11.0	17.0	1.49	1.72	1.2	1.1
1.5 copper	11.0	17.2	2.58	3.09	2.77	1.36
0.4 zinc	11.0	17.2	17.92	1.75	1.92	1.76
1.2 "				1.37	2.35 (esti- mated)	1.61 "
1.2 "				1.37	1.95	1.3

As we already saw,  $\exp(-\gamma)$  values given in Table 1  
 + <sup>will</sup> represent those for which the probability of secondary parti-  
 cles which are  $\gamma$  times as large as the incident electron  
 is absorbed in the foil is unity; the  $\gamma$  values  
 values of the velocity are those for the 3 particles alone,  
 since nearly all the secondary particles are absorbed in the foil.

\* These estimated values were calculated from the curve  
 showing the relation between  $\gamma$  and  $\frac{mV}{e}$ .







per second is  $\frac{1}{2} \pi \nu^2 \lambda^2$  where  $\nu$  is the frequency of the light and  $\lambda$  is the wavelength. The difference between the observed and the calculated values of the pressure is very close agreement, it is in fact only a few per cent. The evidence is entirely electrical in origin, and the speed of light is the limit of the velocity of propagation of the electromagnetic wave. The deviation of the observed value from the calculated value is only over a small range of values of the wave length, and the deviation of values of the pressure is very closely that of the theoretical value, at least until the speed has, for all experimental purposes, practically reached that of light. The deviation of the pressure of the light from the theoretical value is entirely beyond experimental error. Moreover the deviation of the theoretical formulae used to calculate the velocities of the particles from the experimental data are also very small. It is therefore probable that the deviation of the observed value from the calculated value is entirely due to the deviation of the theoretical formulae used to calculate the velocities of the particles from the experimental data.



force is equally well observed. The secondary electron velocity is relatively low, sometimes of the order of the thermal velocity of the gas. A divergence of opinion, especially of the latter, at this stage of the work is to be expected.

However, considering all sources of error the results of Kaufman, together with those of the other workers, are of great weight in the view that the mass of the electron is electrical in origin, and increases with the speed.

Velocity and ratio  $\frac{e}{m}$  for the secondary rays.

It has been assumed in the preceding sections that the velocity of the secondary rays was only slightly less than the primary, and also that they carried the same charge and approximately equal masses. That these facts are true was proved by the following set of experiments.

The general arrangement of the experiment for the purpose of that lead is the case of the primary rays and the same drawings and general description will suffice here. The tube of radium, instead of being placed underneath the slit in the lead box, was shifted to one side



so that no primary rays could be produced. A lead box was placed to the left of the slit so that the right-hand lead plate was the case with the primary rays. A lead diaphragm was placed between the slit of lead, which covered the top of the slit, and the left-hand lead plate, so that the lead box could strike full area of left-hand zinc plate, but was prevented by the strip of lead from falling down to the right-hand plate. The rest of the arrangement was precisely the same as for the ordinary rays, the opening at the electroscopes being arranged so that secondary rays from the lead box could enter.

Secondary rays which strike the left-hand plate, and also the edge of the lead strip produce tertiary rays which travel on with the secondary rays. Great part of these will be absorbed by the mica window and some will get through and cause ionization in the electroscopes. There is also a small part of secondary rays produced by the rays striking the various parts of the apparatus; these, however, do not affect the results since they come from all different parts of the vessel, and are therefore deflected very irregularly.







Coating layer.	$\epsilon$ (max)	$\epsilon$ (min)	$\frac{mV}{e}$	$\frac{e}{m}$	$\frac{e}{m}$
			$1.56 \times 10^{10}$		
paper	$3 \times 10^9$	$10^9$	$1.85$	$1.30 \times 10^{10}$	$1.15 \times 10^{10}$
14 "	$7.5$ "	$17$	$1.97$	$2.10$ "	$1.11$ "
20 "	$7.5$	$17.5$	$1.1$	$1.1$ "	$1.11$ "
20 "	$2.5$ "	$17.5$	$1.3$	$1.1$ "	$1.13$ "









ε  
m

1. *Phragmites australis* (Cav.) Trin. ex Steud.

1900















